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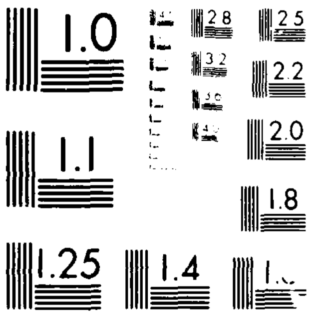
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Six papers have been published in the literature during the past two years, related to the development and performance of the Doppler Lidar Detector System, and its associated wavelength meters. The instrumentation and all of the necessary software is now available at University College London. Three complete Doppler Detector/Wavelength meter units have been fabricated. One of these has been delivered to AFGL, awaiting the completion of the Laser system. Another one of these combined units was integrated temporarily with the complete Lidar system of the Bonn University group at Andoya in August 1987, for proof of concept, and to demonstrate that all of the optical and electronic interfaces and software functioned correctly. Due to limited time in the field, and very poor weather, it was not possible to obtain direct data on the lower thermosphere, but the tests did prove that the entire system functioned as designed. Further tests with Bonn University are planned in 1988.

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COMPONENTS OF AN ATMOSPHERIC LIDAR SYSTEM :
DOPPLER WIND LIDAR

Subject: Resume report of activities conducted under the AFOSR / AFGL grant to University College London 1986/87

Principle Investigator: Dr. David Rees

Co-Investigator: Dr. Russell Philbrick

Inclusive Dates: 1 October 1986 to 30 September 1987

Grant No.: AFOSR-85-0198

Costs and Fiscal Year Source: $27,500

Senior Research Personnel: Dr. David Rees (UGC), Mr. Ian McWhirter (SERC)

Publications: Rees, D, McWhirter, I, Wade, D, "Development of a Doppler Wind Lidar System for Atmospheric Wind Measurements" , 8th Annual ESA / PAC meeting at Sunne, Sweden, May 1987

RESEARCH COMPLETED:

1. Work Immediately Relevant to the Operational Objectives of the AFGL Research Programme.

The equipment to be designed, developed and built during this research programme consisted of two components:

(i) A high precision Wavelength Meter Unit, required to calibrate, monitor and control the precise wavelength of the powerful tunable pulsed laser required for atmospheric sounding (sodium layer); and

(ii) the Doppler Interferometer Detector system, to be mounted in the focal plane of the receiver telescope of the Lidar Sounding Facility. The latter component accurately measures the minute wavelength shifts of the weak signals from the laser scattered from the atmosphere. Analysis of these data provides the height profile of atmospheric wind velocity, when the received signals are cross-referenced in wavelength (by the wavelength meter) to the wavelength of the transmitted lidar beam.

Three complete Doppler Detector Systems and associated wavelength meter units have been successfully fabricated and fully tested, including all of the software required to run these units with a Lidar Sounding System.

One of the complete systems was delivered to AFGL in November 1986, awaiting completion of the stable single-mode tunable laser system, and the programme time to implement the full integration and testing of the wind lidar sounding system.

These complete systems have been demonstrated, during calibrations and by simulations, to meet the requirements and objectives as set out in the original proposal, that is to be able to observe lower thermosphere winds with a height resolution of 200 to 500 meters, a

time resolution of 5 minutes or better, and a wind component accuracy of better than 5 m/sec. (assuming the Lidar performance as specified).

A high-resolution wavelength meter which we have built (similar to the ones for the Doppler Wind Lidar system) has been used very successfully by the Bonn University Lidar Group to calibrate and control the tunable laser of their present Temperature Sounding Lidar, which also observes the natural sodium layer. This lidar sounding system has produced some extremely exciting data in the form of high time and vertical resolution temperature profiles in the region around and above the mesopause. The performance (resolution and stability) of the wavelength meter system, as will be required for the Doppler Wind Lidar, has been an essential feature of the success of the Bonn University Sodium Temperature Lidar sounder.

One of our complete Doppler Detector systems has been fully integrated with the Bonn University Lidar Facility at Andova, Norway in August 1987. The entire system functioned correctly. However, due to limited time available at the station and very poor weather, it was not possible to obtain any "real" atmospheric wind data. A number of problem areas were also identified during this period of integration, where extra effort, particularly in software development, has provided useful system improvements, prior to the deployment of a complete Wind Lidar system for an observational programme. Further tests with the Bonn Lidar are planned for 1988.

2. Future Work.

In the immediate future, the further development of the software of the complete integrated wavelength meter /Doppler Detector is particularly important. In conjunction with Bonn University, we are developing a further refinement of the high resolution wavelength meter, to obtain even greater resolution and wavelength accuracy. This system is expected to be complete by the middle of 1988, and we will then consider whether to retrospectively adapt the device now at AFGL to obtain the same performance. In part, the usefulness of this further refinement depends on the mode stability of the AFGL lidar.

We hope to be able to carry out some of the further development of the Doppler Detector and its software in conjunction with the Bonn University lidar, probably during August 1988. This system will only be able to observe Vertical Winds in the lower thermosphere, due to the limitations of the fixed, zenith-pointing, receiving telescope. However, the opportunity to refine the software, by obtaining actual experimental data will undoubtedly speed the ultimate development of the technique, and simplify the full integration of the AFGL Doppler Lidar, once the full stable and single-mode laser system becomes available.

3. Papers published or in press.

A number of presentations of the status and future development / prospects of the Doppler Wind Lidar Technique have been made: in particular, a review was presented at the ESA / PAC conference at Sunne, Sweden in May 1987, and this will be published in the conference proceedings.

Pre-prints of this paper are being forwarded to AFGL.

SUMMARY:

Six papers have been published in the literature during the past two years, related to the development and performance of the Doppler Lidar Detector System, and its associated wavelength meters. The instrumentation and all of the necessary software is now available at University College London. Three complete Doppler Detector / Wavelength meter units have been fabricated. One of these has been delivered to AFGL, awaiting the completion of the Laser system.

Another one of these combined units was integrated temporarily with the complete Lidar system of the Bonn University group at Andoya in August 1987, for proof of concept, and to demonstrate that all of the optical and electronic interfaces and software functioned correctly. Due to limited time in the field, and very poor weather, it was not possible to obtain direct data on the lower thermosphere, but the tests did prove that the entire system functioned as designed. Further tests with Bonn University are planned in 1988.

We are awaiting the availability of a suitable narrow-band, single mode laser at AFGL, and the necessary mobile or fixed observatory facilities to integrate the Doppler Detector with the transmitting and receiving components of the complete Doppler Lidar System.

The process of refining the software for these systemse is proceeding at University College London, although it will require the experimental stimulus of an observational campaign to finally prove the entire system, and to obtain the desired observational wind data on the lower thermosphere. Although the performance of the entire system has been fully simulated with a suite of computer programmes, the major scientific objective of interest -- lower thermosphere winds -- will not be obtained without direct observation.

With both the Bonn and AFGL systems, the combination of wind and temperature profile data will provide a unique combination of information for understanding the complete interactions between tides, gravity waves and prevailing winds. The combination of the two stations, at widely different latitudes, will provide an excellent means of understanding geographical and seasonal variability.

David Rees. 10 November 1987.

COMPLETED PROJECT SUMMARY

20 NOV 1987

1. TITLE: COMPONENTS OF AN ATMOSPHERIC LIDAR SYSTEM : DOPPLER WIND LIDAR

2. PRINCIPAL INVESTIGATOR: Dr. David Rees, Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT, United Kingdom

PROGRAMME MANAGER and CO-INVESTIGATOR: Dr. Russell Philbrick, Air Force Geophysics Laboratory, Hanscom AFB, Bedford, Massachusetts, USA

3. INCLUSIVE DATES: 1 October 1986 th 30 Septemeber 1987

4. GRANT NUMBER: AFOSR-85-0198

5. COSTS AND FY SOURCE: $27,500 FY 87

6. SENIOR RESEARCH PERSONNEL: Dr. David Rees (UGC), Mr. Ian McWhirter (SERC)

JUNIOR RESEARCH PERSONNEL: Mr. Daniel Wade (AFOSR Grant), Mr. James Percival (UCL), Mr. Paul Hammond (UCL)

7. PULICATIONS:

"Development of a Doppler Wind Lidar System for Atmospheric Wind Measurements," Rees, D, McWhirter, I, Wade, D, presented at 8th Annual ESA / PAC meeting at Sunne, Sweden, May 1987

8. ABSTRACT OF OBJECTIVES (from original proposal):

A three year development project is proposed, in collaboration with the Air Force Geophysics Laboratory, Hanscom Field. The project will be carried out in three phases. The first phase, to be completed by April 1985 will include the development and delivery (to AFGL) of a wavelength meter for calibration of the wavelength and spectral output of a pulsed Nd-Yag or dye laser (pulse by pulse). The accuracy of the wavelength measurement (per pulse) will be 0.01 pm, adequate for the use of a laser system to measure atmospheric temperature with a precision of better than 5 K.

The second phase will include the development and delivery (to AFGL) of an interferometric detection system to be used in the focal plane of the LIDAR receiving system for the direct measurement of mesospheric winds by analysis of the Doppler shift of the back-scattered signal from the LIDAR. Delivery of this detection system, and associated electronics and analysis software is aimed at June 1986.

The third phase will include the integration and testing (at AFGL) of the LIDAR with the new wind-measuring system and the optimisation of the overall lidar transmitting and receiving systems and the computer software. This phase is scheduled for the period between June 1986 and September 1987. The testing phase will be followed by a field observing programme at AFGL. The third phase will include support of several observing programmes between June 1986 and September 1987

using the new active sounder and also using passive ground-based techniques of sounding mesospheric temperature and wind structure with complementary and comparative height ranges to those obtainiable with the lidar system and its new Doppler detector.

The instrumentation to be used in this collaborative project is based on Fabry Perot interferometer techniques which have been developed at UCL during the past decades, including appropriate time-resolved detectors, and electronic and signal processing hardware and software systems.

(For accomplishments, see report)

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